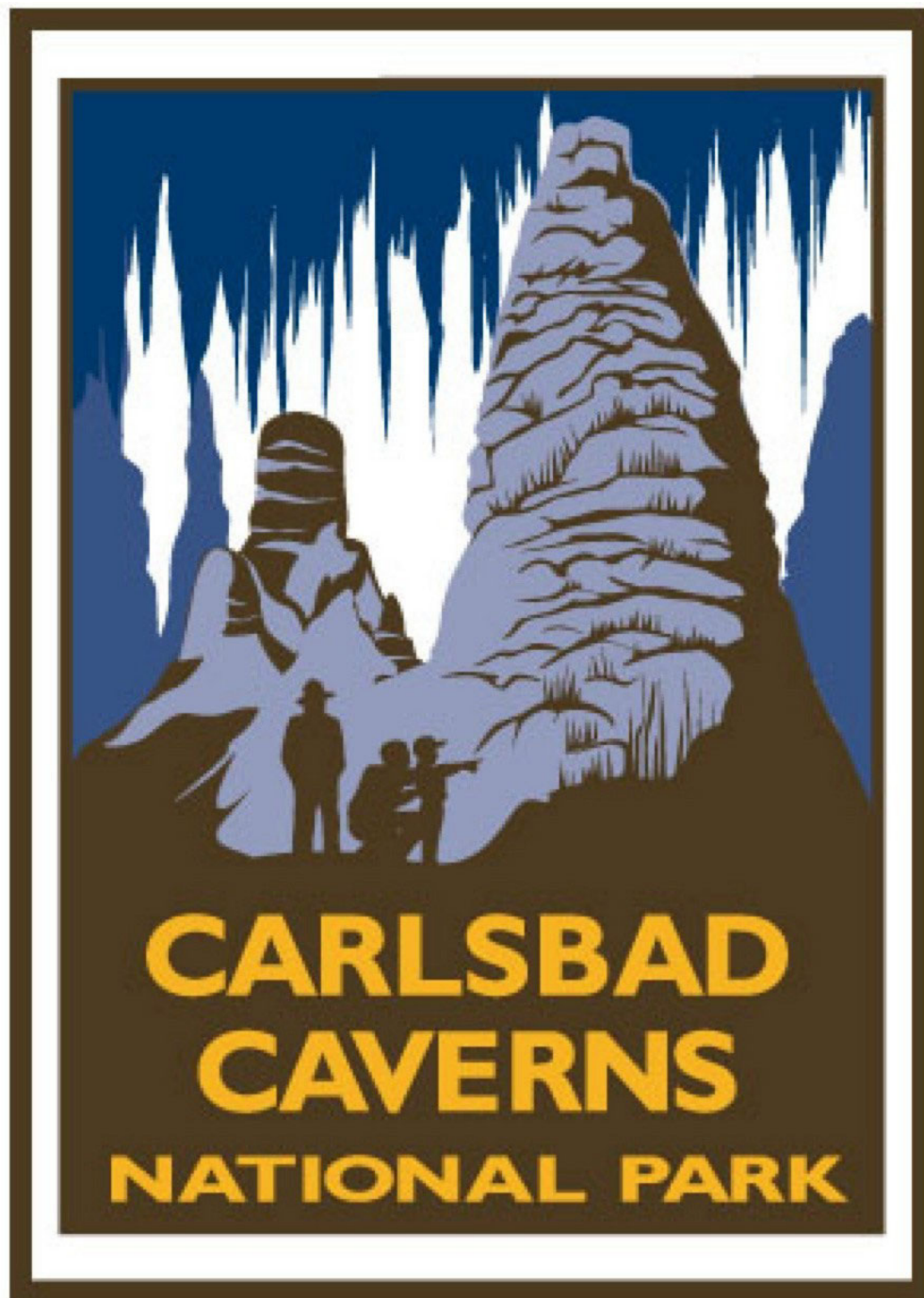


Caves, Canyons, Cactus & Critters

A curriculum and activity guide for Carlsbad Caverns National Park



Middle School Geology



Caves, Canyons, Cactus & Critters

Geology Curriculum

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CONTENT STANDARDS WITH BENCHMARKS

Science

Unifying Concepts and Processes

CONTENT STANDARD 1

Students will understand science concepts of order and organization.

SC1-E1

Students will apply information about the predictability and organization of the universe and its subsystems.

SC1-E2

Students will apply prediction to scientific problems and events.

CONTENT STANDARD 2

Students will use evidence, models, and explanations to explore the physical world.

SC2-E1

Students will identify and organize evidence needed to predict changes in natural and artificial systems.

SC2-E2

Students will organize phenomena into hypotheses, models, laws, theories, principles, and paradigms.

SC2-E3

Students will design and develop models.

CONTENT STANDARD 3:

Students will use form and function to organize and understand the physical world.

SC3-E1

Students will explain function by referring to form and explain form by referring to function.

CONTENT STANDARD 4:

Students will understand the physical world through the concepts of change, equilibrium, and measurement.

SC4-E1

Students will illustrate that constancy and change are properties of objects and processes.

SC4-E2

Students will illustrate that energy and matter can be transformed and changed but the sum remains the same.

SC4-E3

Students will use elementary scientific devices to measure objects and simple phenomena.

SC4-E4

Students will employ mathematics to quantify properties of objects and phenomena.

SC4-E5

Students will relate the contributions of external and internal forces to change in the form and function of objects, organisms, and natural systems.

Science as Inquiry**CONTENT STANDARD 5:**

Students will acquire the abilities to do scientific inquiry.

SC5-E1

Students will use the scientific method within the classroom and school environment.

SC5-E2

Students will employ equipment, tools, a variety of techniques, and information sources to gather, analyze, and interpret data.

SC5-E3

Students will explain that scientific theories emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. Well-accepted scientific theories are formulations of apparent relationships or underlying principles of certain observed phenomena that have been verified to a very high degree.

CONTENT STANDARD 6:

Students will understand the process of scientific inquiry.

SC6-E1

Students will use different kinds of methods, including observation, experiments, and theoretical and mathematical models to answer a variety of scientific questions.

SC6-E2

Students will use their own understanding of science to guide their scientific investigations.

SC6-E3

Students will use criteria for sound scientific investigations to verify the truth of the results of their own and others' investigations.

SC6-E4

Students will choose appropriate methods and analytic techniques for specific science problems and investigations.

SC6-E5

Students will use technology and scientific methods to gather evidence to enhance the accuracy of their findings.

SC6-E6

Students will describe the results of investigations with teachers, peers, parents, and others.

SC6-E7

Students will explain that scientific investigations can result in new ideas, objects, methods, techniques, and procedures for investigation.

SC6-E8

Students will explain that in areas where there is not a great deal of experimental or observational evidence, it is typical for scientists to differ with one another about the theory, hypothesis, or evidence being investigated.

Physical Science**CONTENT STANDARD 7:**

Students will know and understand the properties of matter.

SC7-E1

Students will identify the characteristic properties of elements and compounds such as density, boiling point, and solubility.

SC7-E2

Students will explain that the characteristic properties of an element or compound are independent of the amount (size) of the sample.

SC7-E3

Students will discriminate between elements based on the characteristic ways in which they react with other elements to form compounds that are different substances with unique characteristic properties.

CONTENT STANDARD 8:

Students will know and understand the properties of fields, forces, and motion.

SC8-E1

Students will explain that when an object is not being subjected to a force, the object will continue to move at a constant speed and in a straight line.

SC8-E2

Students will describe quantitatively how an object's position, speed, and direction explain motion.

SC8-E3

Students will compare and contrast gravity to other forces in the world and universe.

CONTENT STANDARD 9:

Students will know and understand the concepts of energy and the transformation of energy.

SC9-E1

Students will apply knowledge about energy and energy transformation to science problems.

SC9-E2

Students will explain how chemical reactions can take place in time periods ranging from less than a second to millions of years.

SC9-E3

Students will explain how chemical reactions involve concentration, pressure, temperature, and catalysts.

Life Science**CONTENT STANDARD 10:**

Students will know and understand the characteristics that are the basis for classifying organisms.

SC10-E1

Students will use information about living things including:

- The roles of structure and function as complementary in the organization of living systems.
- Cells as the fundamental unit of life.
- The functions of cells which sustain life.
- Cell division.
- The use of nutrients by cells.
- The role of heredity and environment in the characteristics of individual organisms.
- Those small genetic differences between offspring and parents may accumulate in succeeding generations and may or may not be advantageous for the species.
- Disease as a breakdown in the structures or function of an organism.

SC10-E2

Students will categorize organisms according to reproductive and other characteristics.

CONTENT STANDARD 11:

Students will know and understand the synergy among organisms and the environments of organisms.

SC11-E1

Students will distinguish among organisms based on the way an organism regulates its internal environment in relation to changes in its external environment.

SC11-E2

Students will describe how organisms obtain and use resources, grow, reproduce, and maintain a stable internal environment while living in a constantly changing external environment.

SC11-E3

Students will predict behavior in relation to changes in an organism's internal and external environments.

SC11-E4

Students will use knowledge of population characteristics to distinguish specific populations.

SC11-E5

Students will categorize organisms based on the function they serve within their ecosystem.

SC11-E6

Students will examine the impact humans have had on other species and natural systems over time.

SC11-E7

Students will illustrate the impact that overpopulation might have on various regions of the world.

SC11-E8

Students will analyze consumption of nonrenewable resources based on population factors (birth rate, death rate, and density).

SC11-E9

Students will illustrate the role of personal control of basic needs on health outcomes.

SC11-E10

Students will model responsible health behaviors for peers and others.

SC11-E11

Students will demonstrate the impact of nutrition and exercise on personal health.

Earth and Space Science**CONTENT STANDARD 12:**

Students will know and understand properties of earth science.

SC12-E1

Students will explain how Earth's materials can be transformed from one state to another.

SC12-E2

Students will experiment with the uses of Earth's materials as resources.

SC12-E3

Students will model natural processes that shape the Earth's surface.

SC12-E4

Students will observe, measure, and record weather changes that occur daily.

SC12-E5

Students will explain how fossils are formed and how fossils provide evidence of the complexity and diversity of life over time.

SC12-E6

Students will use a rectilinear coordinate system such as latitude and longitude to locate points on the surface of Earth.

SC12-E7

Students will describe the interaction between the Earth's lithosphere, hydrosphere, atmosphere, and biosphere.

CONTENT STANDARD 13:

Students will know and understand basic concepts of cosmology.

SC13-E1

Students will model the predictable patterns of the sun and planets in the solar system.

SC13-E2

Students will describe the elements of the universe including stars, galaxies, dust clouds, and nebulae.

SC13-E3

Students will explain various scientific theories for the origin of the universe.

SC13-E4

Students will explain how instruments and vehicles are used for space exploration work.

Technology and the History of Science**CONTENT STANDARD 14:**

Students will know and understand the differences between the interactions of science and technology.

SC14-E1

Students will design and conduct experiments that distinguish between natural and artificial objects and materials.

SC14-E2

Students will demonstrate trade-offs in safety, cost, efficiency, and appearance related to technological solutions provided through science.

SC14-E3

Students will compare and contrast a variety of scientific and technological solutions to problems.

SC14-E4

Students will examine the role of technology, particularly computers and other electronic advances, in the advancement of science.

CONTENT STANDARD 15:

Students will know and understand the impact between science and technology in society.

SC15-E1

Students will illustrate the impact that work settings have on scientific investigations.

SC15-E2

Students will demonstrate how the direction for scientific investigations is related to social issues and challenges.

SC15-E3

Students will explain how the benefits of science and technology are enjoyed by some groups and not by other groups.

SC15-E4

Students will compare and contrast the science contributions of people with diverse interests, talents, qualities, and motivations from a variety of social and ethnic backgrounds.

SC15-E5

Students will predict new areas of scientific inquiry based on previous research.

SC15-E6

Students will analyze the impact of culture, gender, and other factors on an individual's choice of science as a career.

SC15-E7

Students will differentiate between ethical and unethical scientific practices and research.

Science in Personal, Social and Environmental Perspectives**CONTENT STANDARD 16:**

Students will know and understand the relationship between natural hazards and environmental risks for organisms.

SC16-E1

Students will analyze environmental risks for personal and social costs.

SC16-E2

Students will determine options for reducing and eliminating environmental risks and for coping with natural catastrophic events.

SC16-E3

Students will predict the human and financial costs of slow natural events such as drought and rapid natural events such as earthquakes.

SC16-E4

Students will develop models for prevention of substance abuse including tobacco, alcohol, and other drugs, and to reduce the associated environmental risks.

Geology Glossary

A

abrasion: The wearing away of rocks or other materials as they are struck by wind, water, or ice carried sediments.

acid: Naturally occurring chemicals, with a pH less than 7.0, that are aggressive towards carbonate rocks.

alluvial fan: A triangular deposit of sediment left by a stream that has lost velocity upon entering a broad, relatively flat valley.

anaerobic bacteria: Bacteria that utilize some element(s) other than oxygen as a crucial part of their metabolic processes.

anticline: Upward pointing fold in rock.

aquiclude: Impermeable body of rock that may absorb water slowly but does not transmit it.

aquifer: A permeable body of rock or soil that both stores and transports groundwater.

arroyo: A small, deep, usually dry channel eroded by a short-lived or intermittent or intermittent desert stream.

B

bar: Sorted deposit of sediments formed in slower moving portions of stream or river channels.

C

calcareous: Consisting primarily of the mineral calcite (calcium carbonate).

canyon: Name typically given to a steep sided, narrow bottomed, V-shaped, river carved valley.

cave pearl: Concentrically banded concretions that form in shallow cave pools.

cave popcorn: A nodular, globular, or coral-like speleothem.

compression: Stress that reduces the volume or length of a rock, as that produced by the convergence of plate margins.

condensation/corrosion: The process by which water contained in the air and charged with a high level of carbon dioxide condenses out on bedrock or speleothem surfaces and corrodes them.

continental drift: The hypothesis, proposed by Alfred Wegener, that today's continents broke off from a single supercontinent and then plowed through the ocean floors into their present positions. This explanation of the shapes and locations of Earth's current continents evolved into the theory of plate tectonics.

convection cell: The cyclical movement in which heated matter (air, water, mantle material, etc.) becomes less dense and begins to rise. Cooler material, higher up, becomes more dense and begins to sink lower. As it moves lower, it is eventually heated and begins to rise. This cycle is seen in the seasonal air circulation of caves, the earth's mantle, the deep currents in earth's oceans, and in developing thunderstorms.

corrosion residues: Deposits of insoluble residue, or bacterial offal, formed as bacteria "eat" the bedrock of caves. Large deposits are found near Apricot Pit in Lechuguilla Cave, Carlsbad Caverns National Park.

crust: A layer of rock deposited by the sheet flow of saturated water over a cave surface. These crusts can be formed of

calcite (calcium carbonate) or gypsum (hydrous calcium sulfate).

D

deflation: The process by which wind erodes a surface by picking up and transporting loose rock particles.

density: Amount of matter in a given amount of a substance, or mass per unit volume. $d=m/v$

deposition: Process by which sediments are laid down in new locations.

desert pavement: A closely packed layer of rock fragments concentrated in a layer along the earth's surface by the deflation of finer particles.

differential heating: The process by which darker mineral grains in a rock heat at a faster rate than lighter colored grains. The stress this creates between the mineral grains eventually causes them to break apart in a process called intergranular disintegration.

dissolution: A form of chemical weathering in which water molecules, sometimes in combination with acid or another compound in the environment, attract and remove oppositely charged ions or ion groups from a mineral or rock.

E

elastic limit: The limit beyond which the deformation of rock, or other material, becomes permanent and the material will not be able to rebound to its original shape or volume. When the elastic limit of rock is exceeded, it will usually rupture, forming a fault.

escarpment: A steep slope or cliff. Often, these are formed along faults.

evaporite: inorganic chemical sediment that precipitates when the salty water in which it had dissolved evaporates.

extinct: No longer in existence.

extremophile: Bacteria, or other microbes, that live in harsh, extreme conditions.

F

flowstone: A layer of calcium carbonate rock deposited by the sheet flow of saturated water over a cave surface.

frostwork: A needle-like speleothem resembling cactus or thistle plants, or in its composite stalagmitic form, Christmas Trees or fir trees.

G

groundwater: Water found underground.

H

hydrocarbons: A molecule that is made entirely of hydrogen and carbon.

I

ice wedging: A form of mechanical weathering caused by the freezing of water that has entered a pore or crack in a rock. The water expands as it freezes, widening the cracks or pores and often loosening or dislodging rock fragments.

infiltration: The process by which water from precipitation soaks into the soil.

inner core: Solid, innermost layer of the earth.

J

joint: A crack, or break in crustal rock.

K

karst: A landscape characterized by caves, sinkholes, underground streams, and other features formed by the slow dissolving of bedrock.

kerogen: A solid, waxy, organic substance that forms when pressure and heat from the earth act on the remains of plants and animals.

L

lava tube: A cave formed when a tongue of lava, flowing down a marked slope, solidifies on its outer surface, while the interior remains molten and continues to flow. When the liquid lava has drained out of the interior of the tongue, a tubular cavity remains.

lithosphere: A layer of solid, brittle rock comprising the outer 100 kilometers of the earth, encompassing both the crust and the outer-most parts of the upper mantle.

M

mantle: The middle layer of the earth, lying just below the crust and consisting of relatively dense rocks. The mantle is divided into two sections, the upper mantle and the lower mantle.

meander: A bend, or loop, in a river.

mechanical weathering: The process by which a rock or mineral is broken down into smaller fragments without altering its chemical makeup.

microclimate: A small, localized area possessing climatic properties distinctly different from those of the region in general.

model: A symbolic representation of an idea, system, or structure to make something understandable. Models help solve problems and deal with things difficult

to see because they are too large or too small.

Mohorovicic Discontinuity (Moho): The seismic discontinuity between the base of the earth's crust and the top of the mantle. P-waves passing through the Moho change their velocity by approximately one kilometer per second, with the higher velocity occurring in the mantle and the lower in the crust.

mold: Fossil formed in a rock by a dissolved organism that leaves an empty space, showing its outward shape.

monocline: Unidirectional fold in which the rock on one side of the fold has dropped relative to the rock on the other side of the fold.

moonmilk: A soft, microcrystalline substance found in caves. It is plastic and pasty when wet, but crumbly and powdery when dry. It looks and feels like white cream cheese.

N

normal fault: A fault marked by a generally steep dip along which the hanging wall has moved downward relative to the footwall.

O

outer core: Liquid layer of the earth directly beneath the mantle and surrounding the inner core.

P

paleontologist: Scientist who attempts to learn about past environments and organisms by studying fossils.

Pangea: One large landmass of which all continents were once a part, according to the theory of continental drift.

permeability: The capability of a given substance to allow the passage of a fluid.

Permeability depends upon the size and the degree of connection among a substance's pores.

petrified: Having turned to stone.

petroleum: The most common and versatile fossil fuel, comprised of a group of naturally occurring substances made up of hydrocarbons. These substances may be gaseous, liquid, or semisolid.

petroleum trap: Geological situations in which hydrocarbons are produced by a source rock, migrate through a reservoir rock, and are trapped by a cap rock.

plasticity: The ability of a solid to flow.

plate tectonics: The theory that the earth's lithosphere consists of large, rigid plates that move horizontally in response to the flow of the asthenosphere beneath them, and that interactions among the plates at their borders cause most major geologic activity.

pool fingers: Stalactite-shaped speleothems formed subaqueously in cave pools.

porosity: The percentage of a soil, rock, or sediment's volume that is made up of pores.

precipitation: 1. The process by which an element or compound becomes separated from a solution in a solid form. 2. Water that falls from the atmosphere to the earth's surface in the form of rain, snow, sleet, or hail.

R

reef: A ridge that forms in clear, moderately salty seawater near the shoreline and is composed of the carbonate remains of algae, sponges, and corals.

resurging streams: A stream found in a karst area that emerges from underground

through a karst feature such as a cave entrance.

reverse fault: A fault marked by a hanging wall that has moved upward relative to the footwall.

rimstone: Barriers of calcite, aragonite, or other minerals that obstruct cave streams or shallow pools.

root pry: Mechanical weathering process caused by plant roots growing in a crack in a rock.

S

salinity: The amount of dissolved salts in water.

saturation: The state of a fluid when it can hold no more of another substance. Air is saturated when it can hold no more water vapor and clouds form. Cave water is saturated when it can hold no more calcium carbonate and the mineral begins to deposit on speleothems.

sea-floor spreading: The expansion of ocean basins following plate rifting, as new oceanic lithosphere is formed by continuing basaltic eruptions along mid-ocean ridges.

sediment: A collection of transported fragments or precipitated materials that accumulate, typically in loose layers, as of sand or mud.

sedimentary: Of, or pertaining to, sediments.

shear: Stress that slices rocks into parallel blocks that slide in opposite directions along their adjacent sides.

sinkholes: A circular, often funnel-shaped depression in the ground that forms when soluble rocks dissolve.

sinking streams: Formed when streams enter the earth through karst features such as cave entrances or solutionally widened

cracks. Sometimes, the stream will appear to sink into a gravel or sand bed as it descends into a karst system.

slip face: The steep leeward slope of a dune.

slip-strike fault: Faults caused by shearing stress in the block movement is largely horizontal, parallel to the strike of the fault plane. The most famous of North America's slip-strike faults is the San Andreas Fault of the west coast.

soluble: Able to be dissolved in a solvent, usually water.

speleothem: A mineral deposit that precipitates from solution in a cave.

stalactite: An icicle-like mineral formation that hangs from the ceilings of a cave and is usually made up of travertine, which precipitates as water rich in dissolved calcium carbonate drips down from the cave's ceiling.

stalagmite: A cone-shaped mineral that forms on the floor of a cave and is usually made up of travertine, which precipitates as water rich in dissolved calcium carbonate drips down from the cave's ceiling.

stress: The push-pull force acting on a rock or another solid to deform it.

syncline: Downward pointing fold in rock.

T

tension: Stress that stretches or extends rocks, so that they become thinner vertically and longer laterally. Tension is caused by divergence, or rifting.

texture: A description of the size of individual soil particles, the sediment sizes in a sedimentary rock, or crystal sizes in any rock.

trace fossil: Mark or evidence of the activities of an organism.

U

undercut bank: Area along the outer edge of a stream meander in which the erosive action of the stream has cut deep underneath the bank while leaving the upper part of the bank intact.

W

water table: The surface that lies between the zone of aeration and the zone of saturation.

Z

zone of aeration: A region below the earth's surface that is marked by the presence of both water and air in the pores of rocks and soil.

zone of saturation: A region that lies below the zone of aeration and is marked by the presence of water and the absence of air in the pores of rocks and soil.

Suggested Resources

- Ambrose, Janet, et.al. eds. 1999. *About Bats, Caves and Deserts*. Carlsbad, NM: Carlsbad Caverns National Park.
- Chernicoff, S., Fos, H.A., and Venkatakrisnan, R. 1997. *Essentials of Geology*. New York, NY: Worth Publishers.
- Coble, Charles, et al. 1993. *Prentice Hall Earth Science*. Englewood Cliffs, NJ: Prentice Hall.
- Doyle, Peter. 1996. *Understanding Fossils: An Introduction to Invertebrate Paleontology*. New York, NY: John Wiley & Sons, Inc.
- DuChene, H.R., and Hill, C.A. 2000. *The Caves of the Guadalupe Mountains Research Symposium*. In Hose, L.D. (ed.) *Journal of Cave and Karst Studies* 62(2).
- Feather, Ralph, et al. 1999. *Glencoe Earth Science*. Westerville, OH: Glencoe/McGraw-Hill.
- Ford, Brent. 1996. *Project Earth Science: Geology*. Arlington, VA: National Science Teachers Association.
- Hill, Carol and Forti, Paolo, 1997, *Cave Minerals of the World, 2nd ed.* Huntsville, AL: National Speleological Society, Inc.
- Hill, Carol, 1987, *Geology of Carlsbad Cavern and Other Caves in the Guadalupe Mountains, New Mexico and Texas*. Socorro, NM: New Mexico Bureau of Mines & Mineral Resources Bulletin 117.
- Hill, Carol. 1996. *Geology of the Delaware Basin, Guadalupe, Apache, and Glass Mountains, New Mexico and West Texas*: Permian Basin Section SEPM, Publication No. 96-39.
- Jagnow, David and Jagnow, Rebecca. 1992. *Stories from Stones: The Geology of the Guadalupe Mountains*. Carlsbad, NM: Carlsbad Caverns Guadalupe Mountains Association.
- Moore, G.W., and Sullivan, G.N. 1978. *Speleology: The Study of Caves*. Teaneck, NJ: Zephyrus Press, Inc.
- Murck, B.W., Skinner, B.J., and Porter, S.C. 1996. *Environmental Geology*. New York, NY: John Wiley & Sons, Inc.
- Sasowsky, I.D. and Palmer, M.V. 1994. *Breakthroughs in Karst Geomicrobiology and Redox Geochemistry*. Karst Waters Institute, Special Publication 1.
- Shew, R.D. 1998. *Geology of the Guadalupe Mountains*. Guidebook prepared for field seminar/workshop conducted by Guadalupe Mountains National Park and New Mexico State University-Carlsbad.
- Shew, R.D., and Shew, D.M. 2000. *Geology and Natural History of McKittrick Canyon*. Guidebook prepared for workshop conducted by Guadalupe Mountains National Park and New Mexico State University-Carlsbad.
- Smith, R.B. and Siegel, L.J. 2000. *Windows Into the Earth*. New York, NY: Oxford University Press.

Sprinkel, D.A., Chidsey, T.C., and Anderson, P.B., editors. 2000. *Geology of Utah's Parks and Monuments*. Salt Lake City, UT: Utah Geological Association, publication 28.

VanCleave, Janice. 1991. *Janice VanCleave's Earth Science For Every Kid*. New York, NY, John Wiley & Sons, Inc.

Veni, George, et.al. 2001. *Living With Karst*. Alexandria, VA: American Geological Institute Environmental Awareness Series, 4.

Websites of interest:

Science equipment supply companies:

Carolina Biological Supply Company	www.carolina.com
Fisher Scientific	www1.fishersci.com
Flinn Scientific, Inc.	www.flinnsci.com
Sargent-Welch	www.sargentwelch.com

Agencies administering public lands in and near Carlsbad Caverns National Park:

Carlsbad Caverns National Park	www.nps.gov/cave/
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www.carlsbad.caverns.national-park.com/

Guadalupe Mountains National Park	www.nps.gov/gumo/
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www.guadalupe.mountains.national-park.com/

Lincoln National Forest	www.fs.fed.us/r3/lincoln/
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Bureau of Land Management	www.blm.gov/nhp/index.htm
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Sources of information on cave conservation and exploration:

Carlsbad Caverns Guadalupe Mountains Association	www.ccgma.org/
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National Speleological Society	www.caves.org/
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Cave Research Foundation	www.cave-research.org/
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